Lecture

Module 7: Trophic Structure and Energy Flow in Ecosystems

Stan Gregory
Department of Fisheries and Wildlife
Oregon State University

Learning Objectives

Upon completion of this module, the participant will be able to:

1. Identify and describe various trophic levels in both terrestrial and aquatic ecosystems.
2. Discuss patterns of energy flow and transport through the landscape.
3. Describe top-down vs. bottom-up regulation of trophic energy flow.
4. Describe the effects of disrupting networks and energy flow on ecosystem processes.
5. Describe the effects of introducing non-native species on ecosystem structure.

Lecture Outline

Trophic structure in terrestrial and aquatic ecosystems
- Sources of energy
  - Terrestrial sources
    - Leaves and needles
    - Wood
    - Below-ground production
  - Aquatic sources
    - Algal production
    - Vascular macrophytes
    - Mosses
- Trophic levels in both terrestrial and aquatic systems
  - Primary producers
  - Herbivores
  - Carnivores
  - Decomposers

Food webs
- Limits on production of trophic levels
- Top-down versus bottom-up control of food webs or energy flow

River continuum concept
- Patterns of physical processes from headwaters to large rivers
- Patterns of ecological processes from headwaters to large rivers
- River networks
- Floodplains

Flood dynamics
- Flood pulse concept
- Role of floods
  - Aquatic habitats
    - Formation of pools and riffles
    - Creation of complex habitats and wood
  - Floodplain vegetation
  - Nutrient exchange
  - Reproduction and life histories

Effects of disrupting networks and energy flow on ecosystem processes
Effects of introducing non-native species

Exercises

1. The river continuum concept and the nutrient spiraling concept were developed independently. Are these concepts related? Identify any patterns or relationships between these conceptual frameworks.

2. Now, visualize a stream or river in your area. Part of this stream runs through a farm for which you are developing a conservation plan. How would you incorporate the principles of the river continuum concept and nutrient spiraling into your Plan? What upland practices would be relevant to these 2 concepts when choosing a resource management alternative? Discuss how you might use these two ecological concepts to explain the effectiveness of managing pieces of land with a watershed or landscape perspective in mind.

3. Energy flows through ecosystems, and nutrients cycle. Discuss how agronomic practices coupled with conservation corridors could sustain energy flow and efficient nutrient cycling in an agricultural ecosystem to support not only crops but a diversity of plant and animal species as well. Give specific examples of how each practice would contribute to the food web and specific geochemical cycles.

K. Boyer

Study Questions

1. Energy flow through ecosystems and landscapes depends on the interactions of species at different trophic levels, and the relative contribution each species makes toward transferring energy to the next level. Give an example of how an introduced omnivore might affect energy flow in an ecosystem and affect biological diversity, agricultural production, and water quality.

2. Explain the statement: “Connectance declines with species richness.”

3. How do natural disturbances such as fires and floods affect energy flow in ecosystems, both directly and indirectly?

References and Selected Reading

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Slides used in lecture

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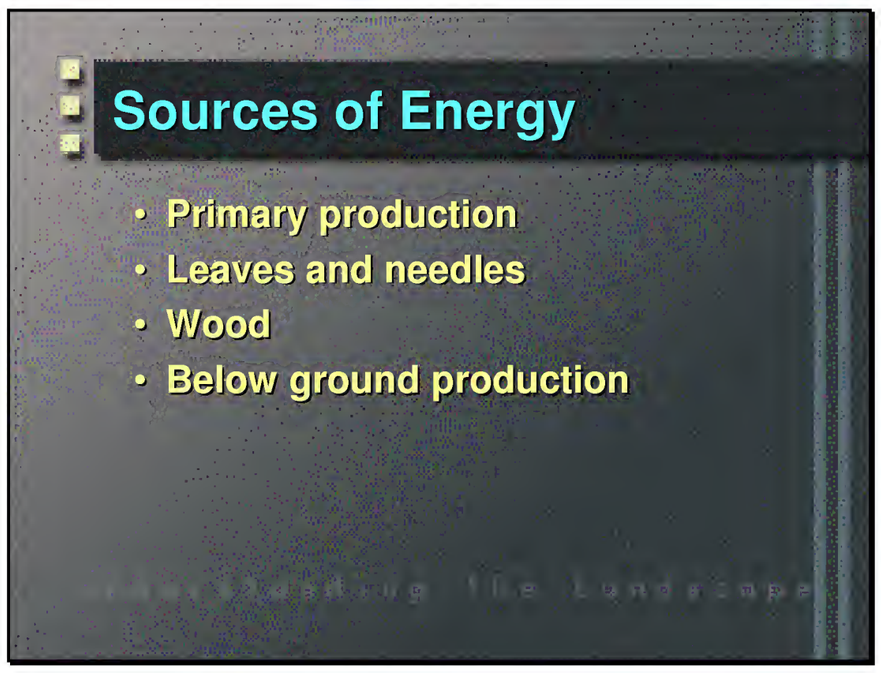

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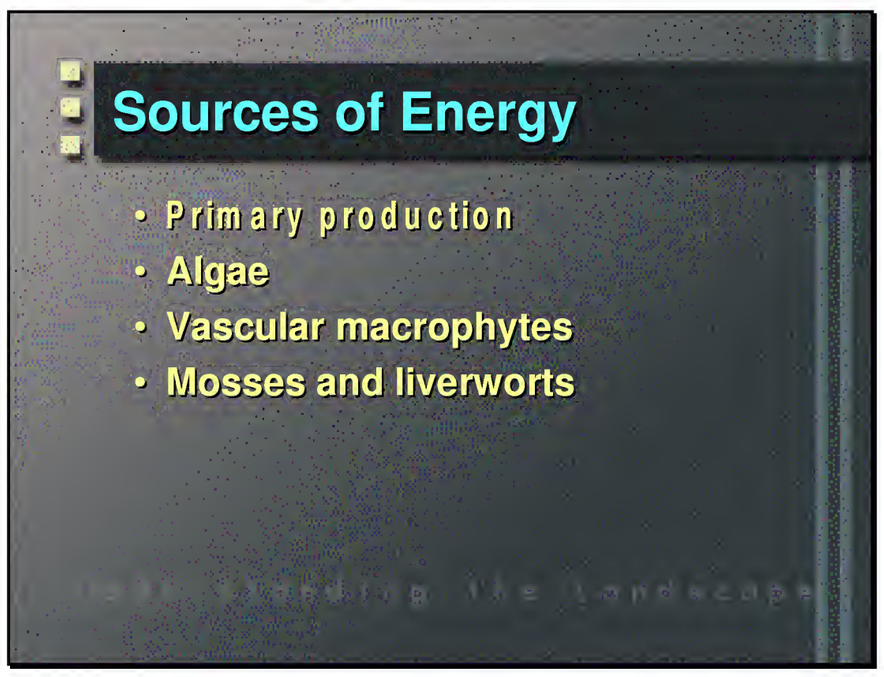

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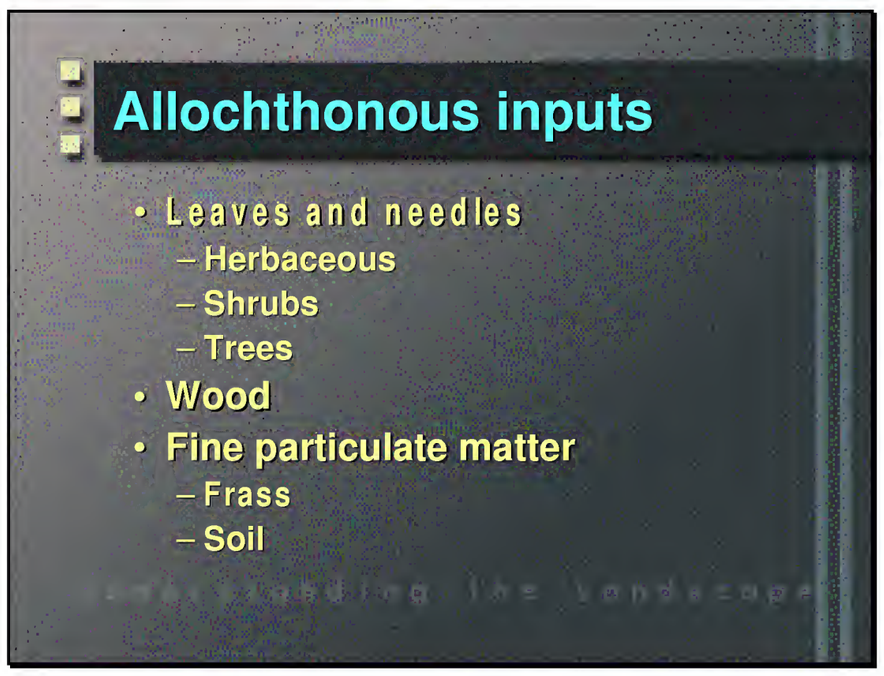

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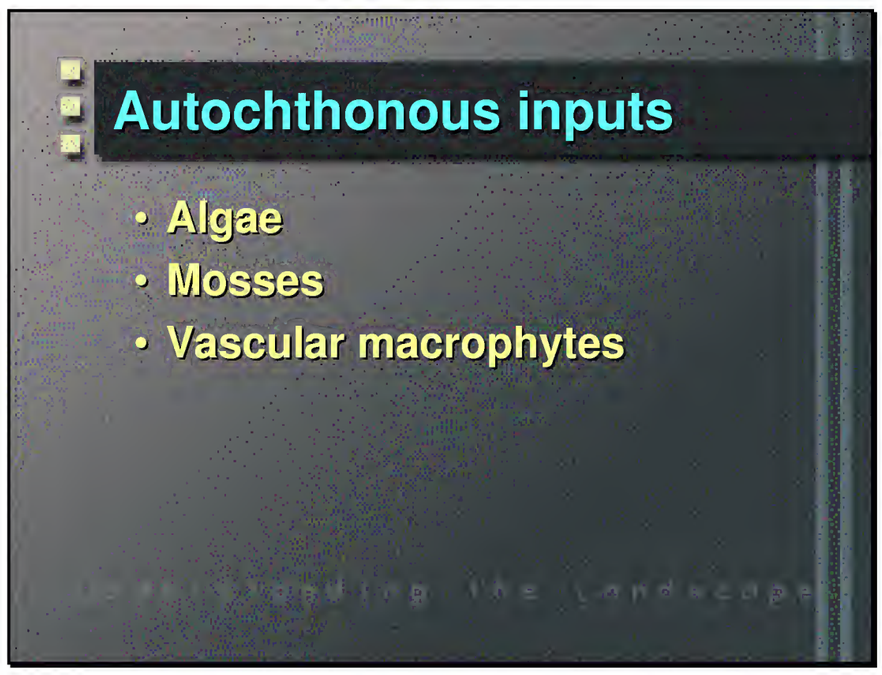

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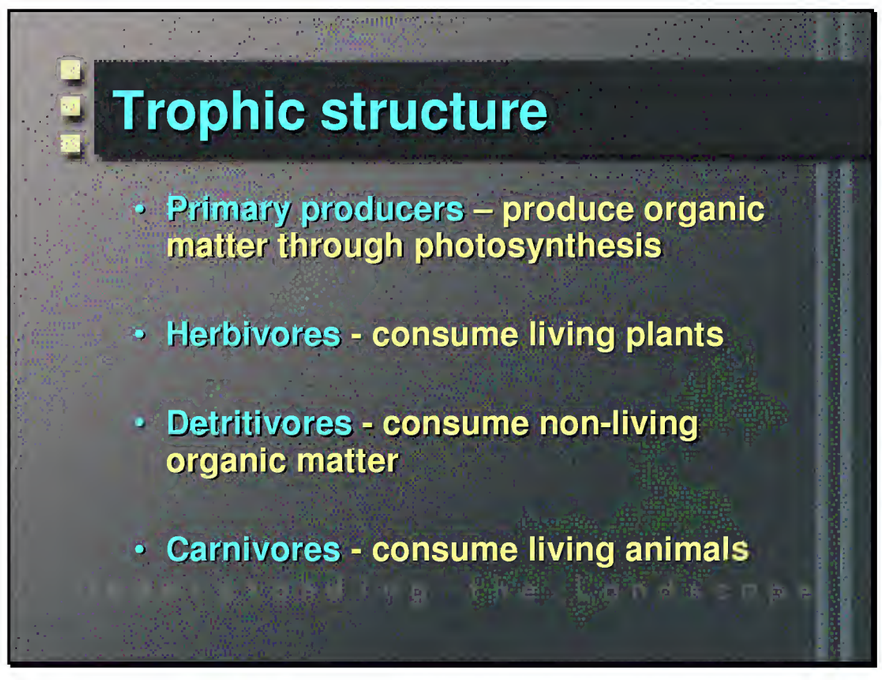

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Feeding Functional Groups

- Scrapers - scrape surfaces of substrates
- Shredders - tear large particles apart
- Collector-gatherers - collect small particles of organic matter
- Predators - engulf other animals

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Food Webs

- Transfer of energy to higher trophic levels
- Limited by efficiency of use
- General rule of thumb is 10% efficiency

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Properties of Food Webs

- Few food webs have more than 3 or 4 levels. Webs are not too complex.
- Connectance (C) usually declines with species richness (S). This is consistent with theoretical models.
- Omnivores are relatively scarce. Typically food chains have one omnivore per top-down predator.
  - Omnivores feed on species in adjacent trophic levels.

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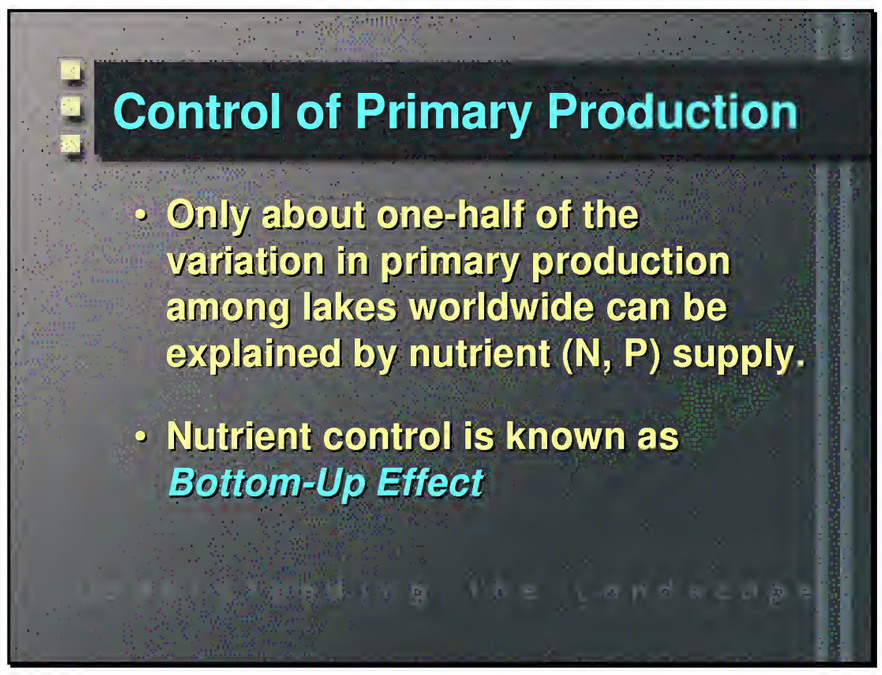

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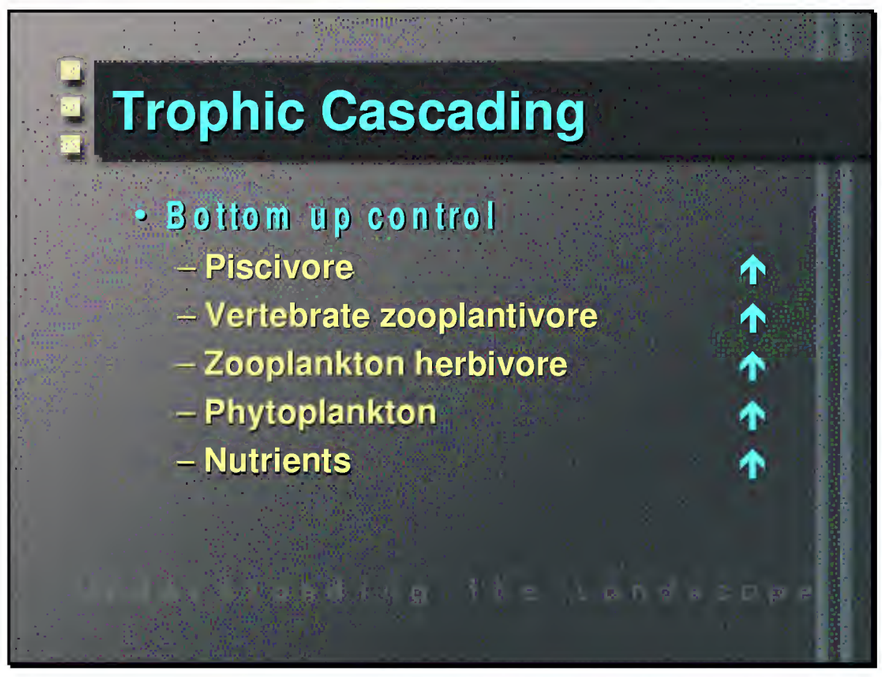

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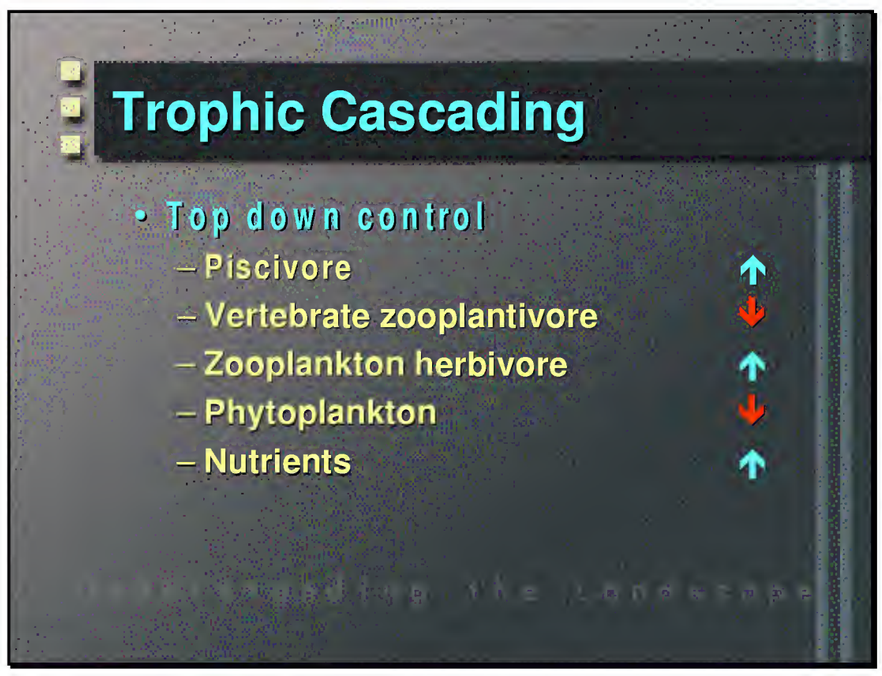

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Cascading Trophic Interactions

- Principles of fishery management can be used to help explain differences in primary productivity among lakes with similar nutrient supplies but different food webs.

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Four Trophic Level System

- Piscivore - fish that consumes other fish, e.g. bass, pike, salmon
- Zooplanktivore - fish that consumes zooplankton
- Herbivore - zooplankton that consume phytoplankton
- Phytoplankton - primary producers

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Top-Down Control

- Rise in piscivore biomass initiates "cascade"
- Planktivore biomass declines
- Large herbivore biomass increases
- Phytoplankton biomass declines

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When It Doesn't Work That Way

- Food webs typically are more complex than simple four-level systems with one representative in each level
- Time lags in response may occur after change in piscivore biomass or reproduction
- Fish can change from zooplanktivory to piscivory with age, thus reversing the cascade

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Case Studies

- Removal of zooplanktivorous fish from lakes, usually by poisoning
- Zooplankton increase
- Phytoplankton and chlorophyll a decline
- Secchi disk transparency increases

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Management Implications

- Stocking of piscivores or harvest of zooplanktivorous fish may be useful for rehabilitating eutrophic lakes
- Represents a blend of fisheries biology, limnology, and water quality management
- In some cases, may substitute for engineering solutions or chemical control of algae

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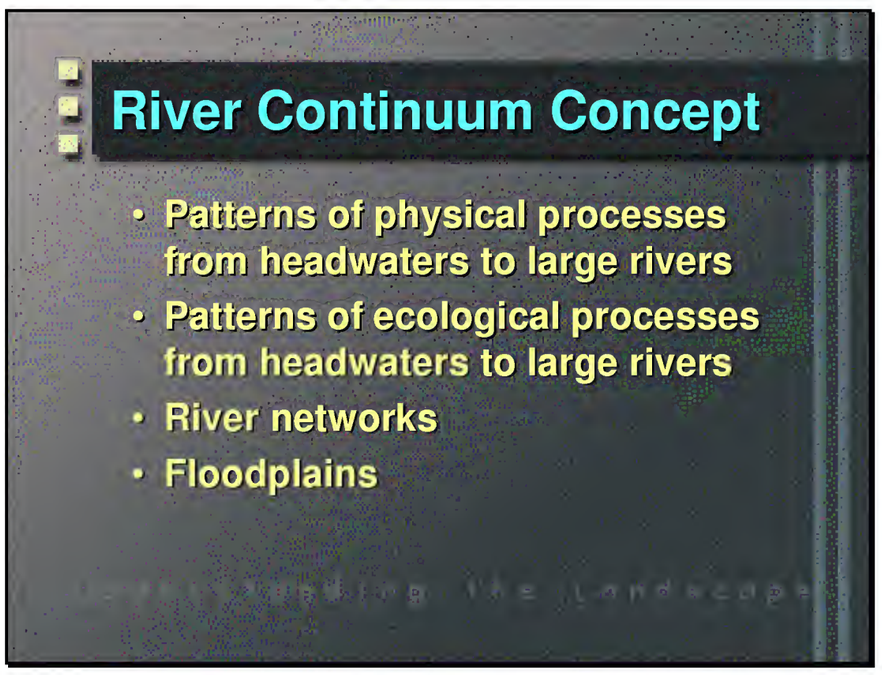

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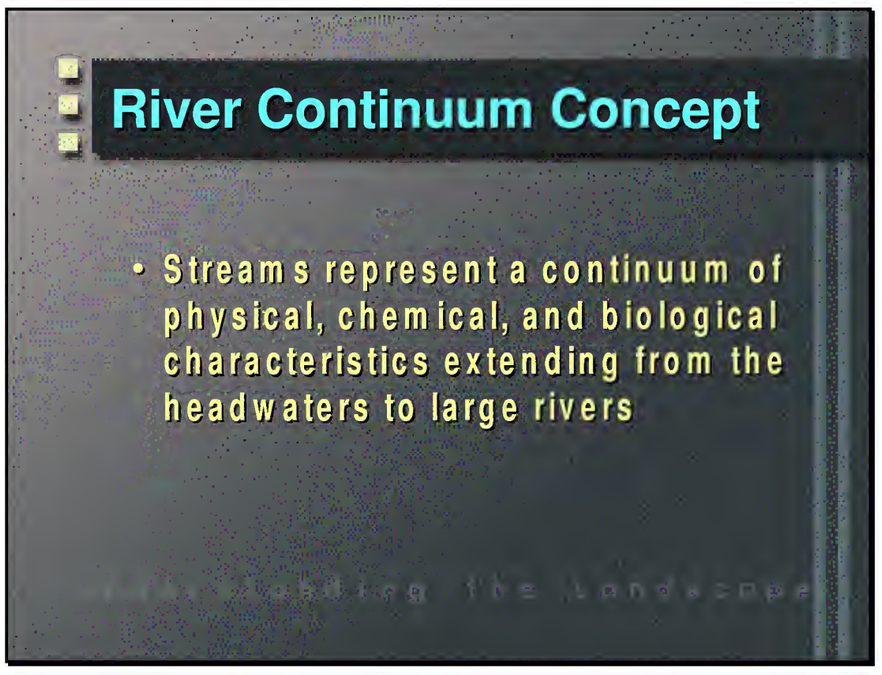

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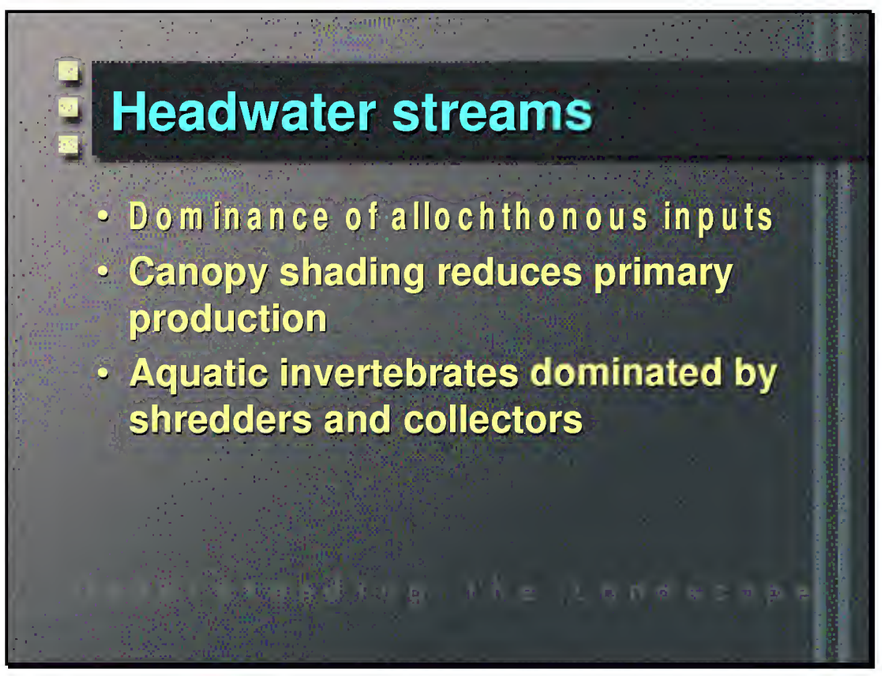

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Larger streams

- Significant inputs of both allochthonous and autochthonous matter
- Aquatic invertebrates dominated by scrapers and collectors

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Rivers

- Shift toward planktonic primary production
- Dominance of fine particulate organic matter
- Aquatic invertebrates dominated by collectors
- Extensive floodplain development

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Riparian Areas

- Legal - streamside
- Linear - edge perspective
- Planar - surface area
- Functional - 3-dimensional zone of influence
- Structural - mosaics of geomorphic surfaces that are created and maintained by disturbance. The geomorphic surfaces and terrestrial plant succession create the riparian area.

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Riparian Areas

- Ecotones
  - Interfaces between adjacent ecosystems

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Flood Dynamics

- Role of floods
- Aquatic habitats
- Formation of pools and riffles
- Creation of complex habitats and wood
- Floodplain vegetation
- Nutrient exchange

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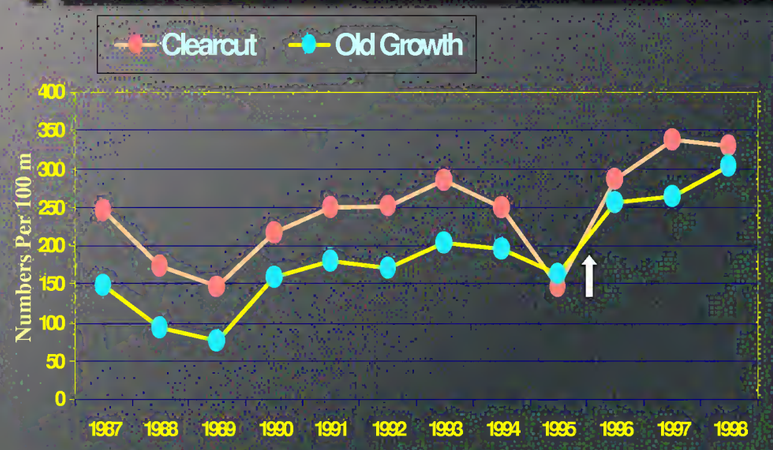
Cutthroat in Mack Creek



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Flood Pulse Concept

- The pulsing of river discharge is the major force controlling biota in river floodplains.

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Flood Pulse Concept

- Floodplains are areas that are periodically inundated by the lateral overflow of river or lakes, and/or by direct precipitation or groundwater.
- The resulting environment causes the biota to respond by unique adaptations and produces characteristic community structures.

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Aquatic/Terrestrial Transition Zone

- Area that alternates between aquatic and terrestrial systems
- The moving littoral zone is the inshore edge of the aquatic environment

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Flood Pulses in Rivers

- Long-duration flooding
- Short-duration floods
- Flash floods

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Definition

- Disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment.

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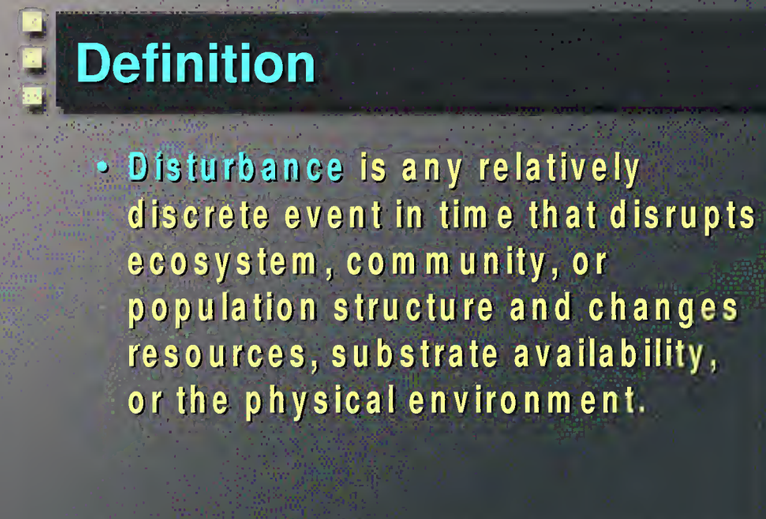
Intermediate Disturbance Hypothesis



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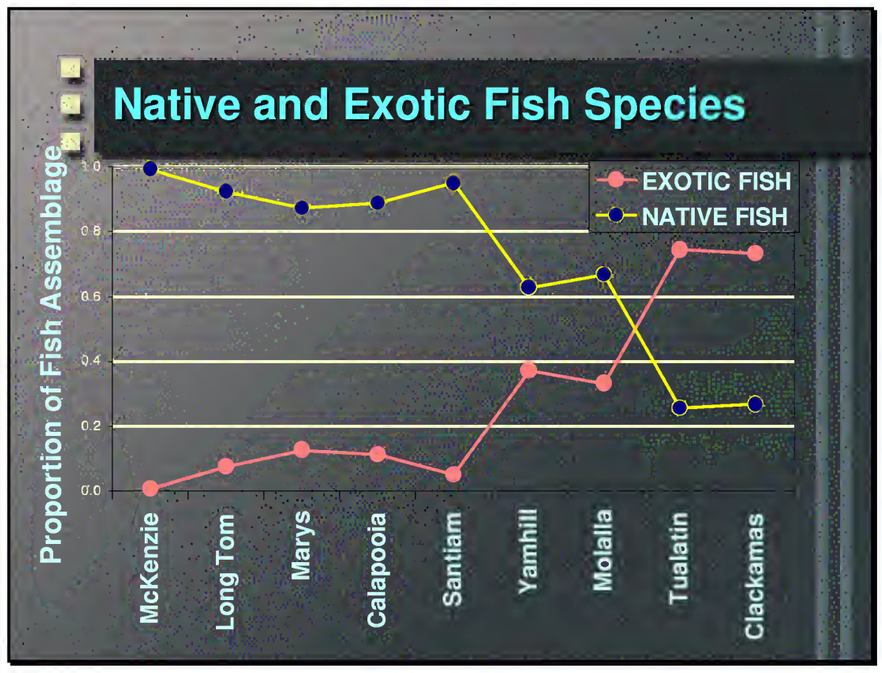
Native and Exotic Fish Species
Proportion of Fish Assemblage
1.0
0.8
0.6
0.4
0.2
0.0
EXOTIC FISH
NATIVE FISH
McKenzie
Long Tom
Marys
Calapooia
Santiam
Yamhill
Molalla
Tualatin
Clackamas